DDG-52AF Vacuum Collection, Holding And Transfer (VCHT) System Problems

Crew Brief

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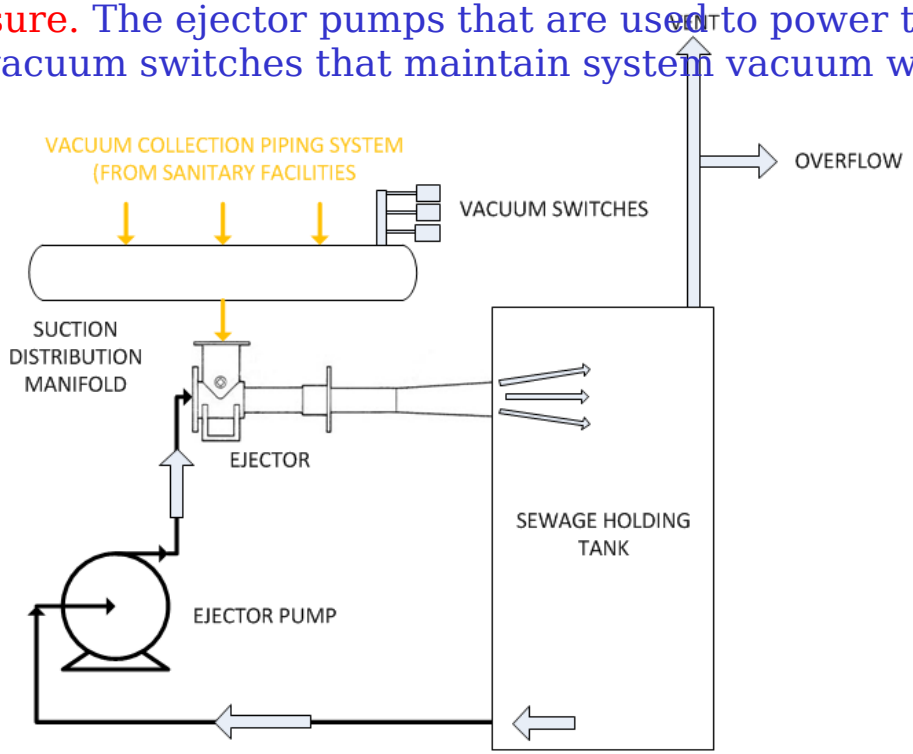
Background

DDG-52 VCHT Systems

- Two independent VCHT systems per ship (forward and after systems)
- Sewage collection piping system under vacuum (12-18 inches mercury (Hg))
- Vacuum subsystem collects wastes from vacuum water closets and urinals equipped with vacuum-interface-valves (VIVs)
- Vacuum generated by sewage powered ejectors provided with pumps that are required to be available 24/7/365
- VCHT system sewage holding tank at atmospheric pressure
- Gravity plumbing waste drains (sinks, showers, deck drains, laundry, etc.) above the waterline can be collected in plumbing waste collection tank (normal configuration), VCHT system sewage holding tank, or diverted overboard (in transit or outside restricted waters)
- Gravity plumbing waste drains below the waterline must be collected in in plumbing waste collection tank (normal configuration) or VCHT system sewage holding tank at all times
- Ship's laundry drains to after VCHT system pump room. These drains should be aligned for collection in the after plumbing waste collection tank.

Sewage Powered Ejector and Ejector Pump

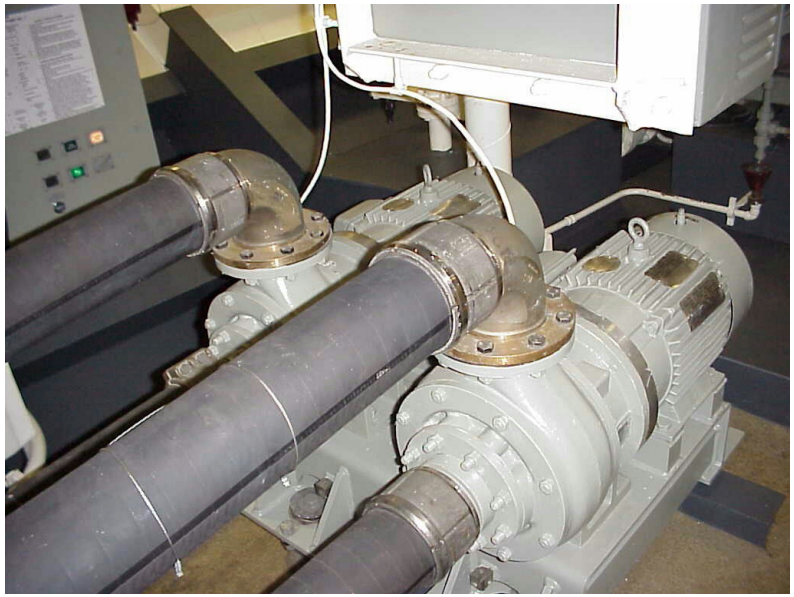
The sewage powered ejector system generates vacuum by pumping sewage from the bottom of the sewage holding tank by ejector pumps through ejectors, back into the top of the sewage holding tank. The vacuum collection piping system is connected to the suction side each ejector via a suction distribution manifold and a non-return valve at the each ejector suction inlet. Sewage flows through the an ejector nozzle within the ejector body creating a differential pressure which allows the ejector to remove air from the collection piping (the holding tank is not under vacuum). When the ejector system is not running, the non-return valve isolates the vacuum collection piping from the holding tank, which is at atmospheric pressure. The ejector pumps that are used to power the ejectors are controlled by three vacuum switches that maintain system vacuum within operating requirements.



Background

Sewage Ejector Pump

The Herborner VCHT system ejector pumps are used on CVN-77, LCS-1, DDG-52AF, PC-1, and LPD-17 Classes. This pump experiences heavy service (frequent start/stopping) under normal conditions, long run times with system problems (vacuum leaks, vacuum pressure switch problems), clogged ejector inlet piping, and are required to be available 24/7/365.



Sewage Ejector Pumps

VCHT System Issues

Technical

- Vacuum leaks (piping connections, clogged ejectors)
- Vacuum pressure switch issues
- Excessive foam generation and overboard discharge of foam
- Excessive ejector pump run times and high ejector pump failure rate (due to vacuum leaks, vacuum pressure switch issues, excessive foam)
- Gray water system backflooding and overboard discharge of foam from VCHT tank overboard overflow
- Scale build-up in collection piping (clogged ejector non-return valves, poor drainage)

Cost

- Four ejector pump/motor assemblies per ship
- New ejector pump and motor assembly cost approximately $60K each
- Maintenance and repair labor (chemical cleaning, replacing pumps, looking for vacuum leaks, troubleshooting, etc.)

VCHT System Availability

- Ejector pumps needed for vacuum collection of wastes from vacuum water closets and urinal equipped with vacuum interface valves (VIVs)
- Ejector pumps required to be available at all times (24/7/365)

Safety and Health

- Potential exposure to sewage (when replacing/repairing ejector pumps, cleaning components, etc.)

Vacuum Leaks and Ejector Clogging

- **System vacuum leaks (vacuum water closet and urinal VIV connections, ejector non-return valve) and ejector clogging**

  Vacuum leaks are a costly problem associated with VCHT systems since they are often a root cause of numerous material issues and in many instances difficult to locate. System vacuum leaks can cause ejector pumps to run excessively (leading to increased wear and tear) and also lead to excessive foam generation in the VCHT sewage holding tank. One common type of system vacuum leak occurs at the ejector's non-return valve. The non-return valve is the VCHT system's "interface" between the vacuum side of the system (collection piping) and ambient pressure side of the system (the sewage holding tank which on DDG-52 AF ships is NOT under vacuum). When an ejector pump IS NOT running, the non-return valve isolates the vacuum collection piping from the sewage holding tank, which is at atmospheric pressure. Vacuum in the collection piping pulls th[illegible] of the housing. Any build-up of solids or any
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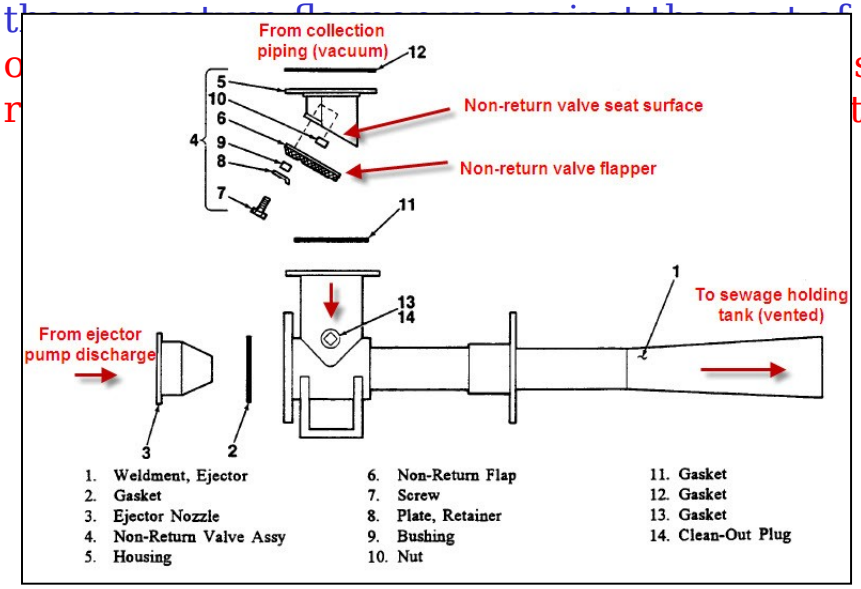


Ejector Assembly Parts Diagram

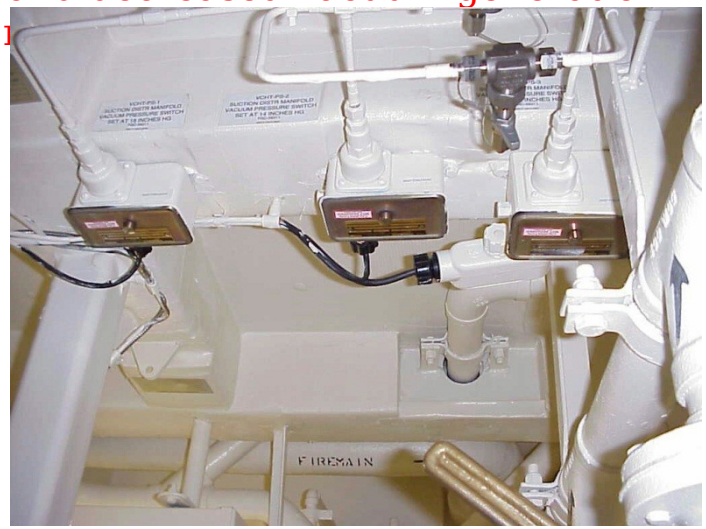
Ejecto

Vacuum Pressure Switch Issues

- **Vacuum pressure switch issues (clogged and/or incorrectly set)**

  Vacuum switches control the operation of the ejector pump operation and are set at 12 mercury (Hg) (standby pump cut-in), 14 Hg (duty pump cut-in), and 18 Hg (pump(s) cut-out). Direct exposure of the vacuum pressure switch ports to sewage can account for erratic ejector pump operation and excessive runtimes. Erratic ejector pump operation typically involves clogged or malfunctioning cut-in switches and can be time consuming to troubleshoot, while a clogged or malfunctioning cut-out switch typically results in the ejector pumps failing to de-energize. This excessive pump runtime results in increased fo[illegible]ks and decreased vacuum generation e[illegible]or r[illegible] c[illegible]

Severely Eroded Ejector Pump Impeller



Vacuum Pressure Switches

Foam Generation

Causes and Impacts

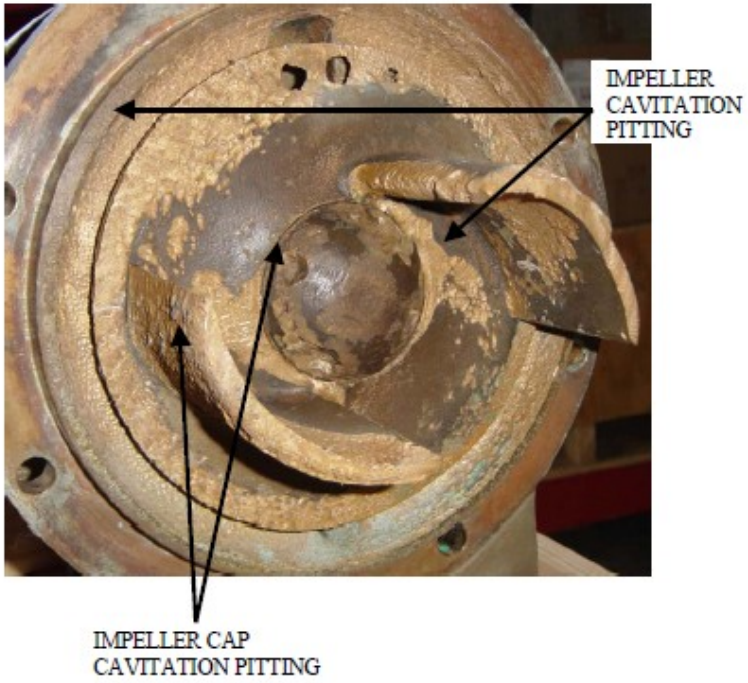
- **Foam** is generated from the agitation of any detergents/cleaners in the VCHT sewage holding tank contents by the ejectors.
- **Excessive foam** is the result of ejector pumps running excessively (because of system vacuum leaks, clogged ejectors, vacuum pressure switch issues, airbound conditions) and/or excessive amounts/high concentrations of detergents/cleaners in the VCHT sewage holding tank. Ejector pumps running excessively also elevates the temperature of the VCHT sewage holding tank contents which also contributes to excessive foam generation.

- **Excessive foam can:**
  - be ingested by sewage transfer and ejector pumps, resulting in them becoming airbound.
  - pressurize the VCHT sewage holding tank and the tank's overboard/vent piping. This can result in backflooding of gravity plumbing waste drains if aligned for collection in the sewage holding tank.
  - discharge overboard or out of tank vent piping. Any discharge of sewage (or sewage contaminated foam) in port is unacceptable (safety and environmental compliance)

Excessive Foam Generation Impact

- **Ejector Pump**

  System vacuum leaks and vacuum pressure switch issues can cause ejector pumps to run excessively (leading to increased wear and tear) and also lead to excessive foam generation in the VCHT tank. Foam is produced from the agitation of any detergents/cleaners in the sewage holding tank contents by the ejectors. This foam can also become ingested by the sewage transfer and ejector pumps, resulting in them becoming airbound (thus unable to move fluid through the ejector nozzles) and any resulting cavitation ca



Cavitation Pitting on Ejector Pump Impeller

Excessive Foam Generation Impact

Overboard discharge and out of tank vent piping

Foam out of tank overboard on DDG-51 Class ship

Typical tank vent termination on weather deck on DDG-51 Class ship (bellmouth fitting and mesh screen)

Excessive Foam Generation

Recommended Corrective Actions and Preventative Measures

- **Proper use** of approved fixture (vacuum water closet and urinal) cleaners in accordance with the Ship's Hazardous Material List (SHML). Each ship is assigned an applicable type-SHML (or T-SHML) providing a listing of hazardous material authorized for use on that specific ship.
- **Proper disposal** of waste water generated from routine maintenance evolutions such the cleaning of berthing space and sanitary space decks. This waste water (which can contain high concentration of cleaners) should be disposed of via the ship's gray water system and not allowed to enter the VCHT system via vacuum water closets and urinal fixtures.
- **Activation** of the VCHT system sewage holding tank system and sewage transfer pumps to lower the fluid and foam levels in the sewage holding tank. The cold firemain water will help knockdown the foam. Note: The sewage transfer pumps may have already become airbound as a result of ingesting foam and may require re-priming.
- **Locate** and **fix** system vacuum leaks through manual system isolation or use of vacuum leak detector.
- **Ensure** the main plumbing waste diverter valve in the VCHT pump room is aligned to collect plumbing waste in the plumbing waste collection tank NOT the VCHT system sewage holding tank. Wastes from plumbing waste sources contain high concentrations of soapy wastes (shampoos, body washes, etc.).

Locating Vacuum Leaks - Manual Method

1) Close the two VCHT system collection piping isolation valves (Figure 1) connected to the suction distribution manifold in the sewage pump room. This will isolate collection

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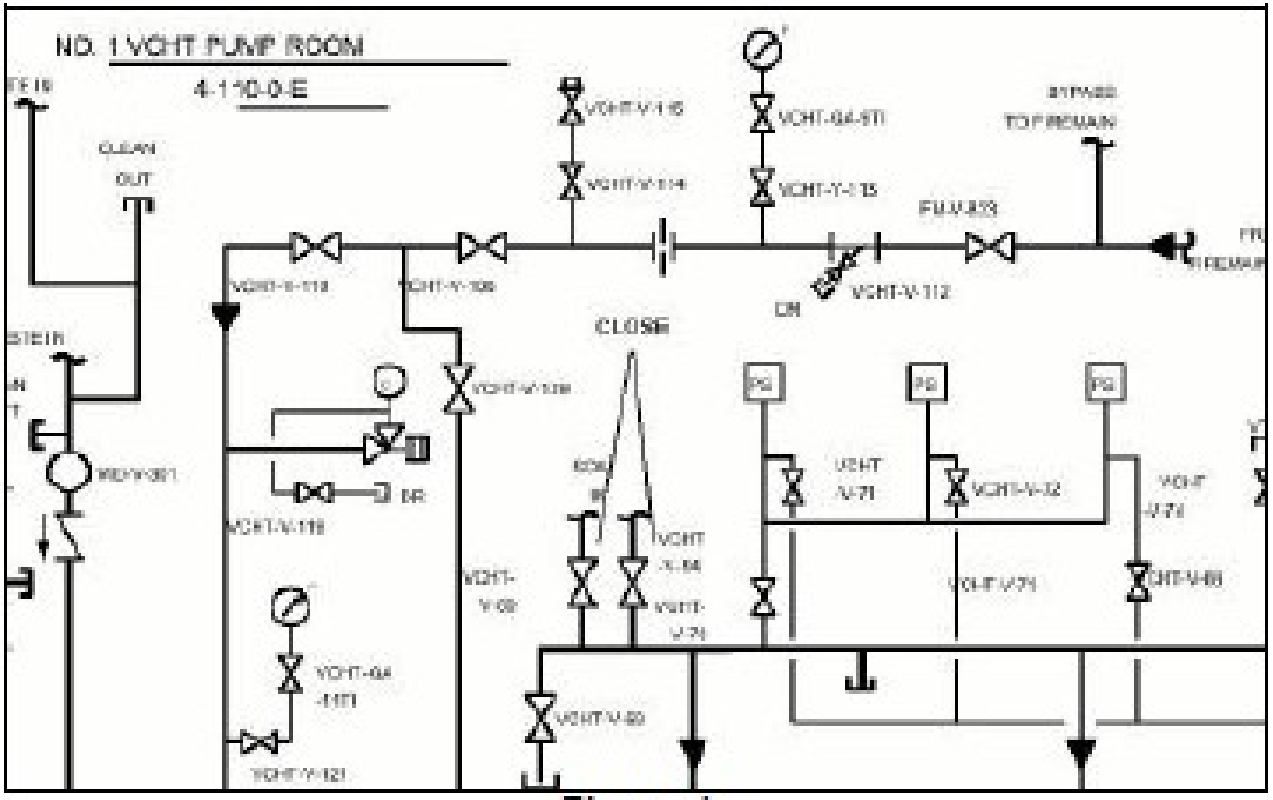

Figure 1

Locating Vacuum Leaks
- Manual Method (Continued) -

2) Observe the VCHT system vacuum gauge (Figure 2); if the vacuum level remains stable, vacuum leak(s) exist in the collection system (piping, valves, water closets, urinals, and VIVs). If the vacuum level decreases, vacuum leak(s) exist in the pump room (piping, valves, ejector non-return v

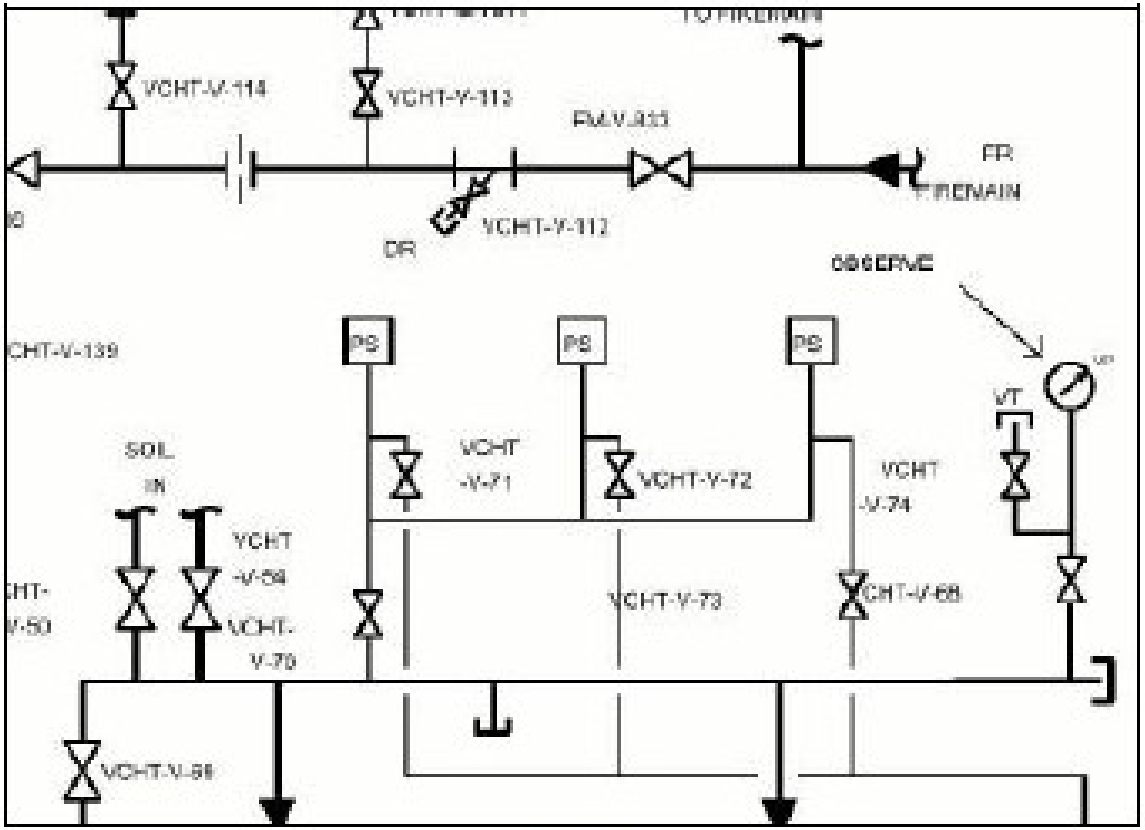

Figure 2

Locating Vacuum Leaks
- Manual Method (Continued) -

3) To locate vacuum leaks in the collection system, secure all sanitary spaces and then
open one of the two VCHT system collection piping isolation valves connected to the
suction distribution manifold in the sewage pump room.

4) Starting at the highest sanitary space and working down, close sanitary space
collection piping isolation valves associated with the open VCHT system collection piping
isolation valve in the sewage pump room until VCHT system vacuum levels stabilize. Use
the ship's SDOSS as a guidance for applicable valve locations. The leaks(s) will be
located in collection piping or components upstream of the last isolation valve closed.
Vacuum leaks produce sounds in check valves (metallic sound) that are located in
collection piping and failed outlet piping (hissing sound) from vacuum

Locating Vacuum Leaks
- Manual Method -

5) If no leaks are found, repeat steps 3 and 4 for the remaining VCHT collection system

isolation valve connected to the suction distribution manifold in the sewage pump room.

6) To locate vacuum leaks in the sewage pump room, ensure the two VCHT system

collection piping isolation valves connected to the suction distribution manifold are still

closed. Then, systematically close pump room piping isolation valves to the suction

distribution manifold until VCHT system vacuum levels stabilize. The leaks(s) will be

located in pump room piping or components upstream of the last isolation valve closed.

Locating Vacuum Leaks
- Vacuum Leak Detector -

- NSWCCD Code 631 accomplished successful land-based and shipboard testing (on some DDG-51 Class ships) of a commercially-available ultrasonic leak detector (presently available in the stock system). This commercial vacuum leak detection device has shown to provide the capability to **quickly locate vacuum leaks** that cannot be detected by **conventional labor-intensive and time consuming methods**. NSWCCD Code 631 issued an In-Service Engineering (ISE) Advisory No. 001-10 (VCHT Leak Detection Device (071539ZJAN10)) on this ultrasonic leak detector that provides ordering, NSN, APL, and PMS information for those ships able to procure them.

- This advisory only **recommended** the use of the leak detector as a **troubleshooting tool** and **did not authorize** their purchase or supply them to the Fleet.

- **Unscheduled** Maintenance Requirement Cards (MRCs) were added to affected ship class MIPs (DDG-51, LPD-17, and PC-1 Classes, and hulls LCS-1, LCS-2 and CVN-77) and SPMIG numbers were generated, to complete a suite of ILS changes (APLs, NSTM 593, etc.)

In-Service Engineering (ISE) Advisory No. 001-10 (VCHT Leak Detection Device (071539ZJAN10))

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PEO CARRIERS WASHINGTON DC//PMS312//
PEO SHIPS WASHINGTON DC/PMS317//PMS317/PMS400D/PMS501//
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SHIPSUPPACT NORFOLK DET NAPLES IT//210//
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SOUTHWEST RMC SAN DIEGO CA//200/300/900//
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SUBJ/IN-SERVICE ENGINEERING (ISE) ADVISORY NO. 001-10, VACUUM, /COLLECTION, HOLDING AND TRANSFER (VCHT) LEAK DETECTION DEVICE//
REF/A/DESC:CON/NAVSEA/28OCT2009//
AMPN/REF A IS MEETING BETWEEN NAVSEA 05P25/PETE MCGRAW AND NSWC 631/ERNIE DURELL//
POC/A. PROUDFOOT/CIV/UNIT:NSWCCD-SSES 631/NAME:PHILADELPHIA /TEL:215 897-1397/EMAIL:AUDREY.PROUDFOOT@NAVY.MIL//
GENTEXT/REMARKS/1. PURPOSE: TO ANNOUNCE THE AVAILABILITY OF A COMMERCIAL DEVICE THAT CAN BE USED TO LOCATE VACUUM LEAKS IN SHIPBOARD VACUUM, COLLECTION, HOLDING AND TRANSFER (VCHT) SYSTEMS.
2. BACKGROUND:
A. VACUUM LEAKS ARE A COSTLY PROBLEM ASSOCIATED WITH VCHT SYSTEMS, SINCE THEY ARE OFTEN A ROOT CAUSE OF NUMEROUS MATERIAL ISSUES AND IN MANY INSTANCES DIFFICULT TO LOCATE. VACUUM LEAKS CAUSE VCHT SYSTEM EJECTOR PUMPS TO OPERATE EXCESSIVELY (ADDITIONAL WEAR AND TEAR), DECREASE VACUUM GENERATION EFFICIENCY (DUE TO ACCELERATED WEAR OF VCHT SYSTEM EJECTOR NOZZLES) AND CONTRIBUTE TO EXCESSIVE FOAM PRODUCTION IN SEWAGE HOLDING TANKS. EXCESSIVE FOAM CAN BE PRODUCED BY THE COMBINATION OF SOAPY WASTES IN THE SEWAGE HOLDING TANK AND EJECTOR PUMPS OPERATING CONSTANTLY WHEN ATTEMPTING TO MEET ABNORMAL SYSTEM VACUUM DEMANDS (FREQUENTLY CAUSED BY VACUUM LEAKS). THE OVERBOARD DISCHARGE OF FOAM FROM A SEWAGE HOLDING TANK (VIA THE TANK OVERFLOW) CAN BE CONSIDERED AN OVERBOARD SEWAGE DISCHARGE FROM THE SHIP. ANY OVERBOARD DISCHARGE OF SEWAGE (OR SEWAGE CONTAMINATED FOAM) IN-PORT IS UNACCEPTABLE AND PROHIBITED BY OPNAVINST 5090.1C (ENVIRONMENTAL AND NATURAL RESOURCES PROGRAM MANUAL).
B. CONVENTIONAL METHODS OF LEAK DETECTION IN VCHT SYSTEMS INCLUDE SPRAYING LIKELY LOCATIONS (PIPING, FLANGES, ETC.) WITH A SURFACTANT (SOAPY) SOLUTION AND OBSERVING FOR THE APPEARANCE OF BUBBLES. ANOTHER METHOD INVOLVES ISOLATING THE SYSTEM VACUUM PIPING AND OBSERVING THE VCHT SYSTEM VACUUM GAUGE FOR CHANGES IN VACUUM LEVELS. BOTH METHODS ARE LABOR INTENSIVE, TIME CONSUMING AND MAY ONLY PROVIDE A GENERAL LOCATION FOR A LEAK. IN ADDITION, SINCE MOST VACUUM LEAKS ARE SMALL AND PRODUCE ULTRASONIC SOUND (SOUND AT FREQUENCIES OVER 20 KHZ THAT ARE NOT DETECTABLE BY THE HUMAN EAR) A TROUBLESHOOTING DEVICE WAS NEEDED TO LOCATE THESE TYPES OF LEAKS.
3. RECOMMENDED ACTION: UTILIZE THE NEWLY AVAILABLE CTRL UL101 ULTRASONIC VACUUM LEAK DETECTION DEVICE FOR VCHT SYSTEM LEAK DETECTION.
A. ULTRASOUND IS VERY DIRECTIONAL (THE SOURCE OF A PROBLEM CAN BE PINPOINTED MORE ACCURATELY) AND IT STAYS CLOSE TO ITS SOURCE ALLOWING FOR EASIER DETECTION BY COMMERCIALLY AVAILABLE ULTRASONIC LEAK DETECTORS. ULTRASONIC LEAK DETECTORS CONVERT THE ULTRASOUND PRODUCED BY VACUUM LEAKS INTO SOUND FREQUENCIES BELOW 5 KHZ (WITHIN THE HUMAN RANGE OF HEARING) AND ARE ALSO EQUIPPED WITH VISUAL INDICATORS TO HELP IDENTIFY THE SOURCE OF A LEAK.
B. THE CTRL UL101 WAS TESTED IN LAND-BASED AND SHIPBOARD VCHT SYSTEMS BY NSWCCD-SSES 631, AND IT HAS SHOWN TO PROVIDE THE CAPABILITY TO QUICKLY LOCATE VACUUM LEAKS THAT CANNOT BE DETECTED BY CONVENTIONAL LABOR-INTENSIVE AND TIME CONSUMING METHODS. THE CTRL UL101 (AVAILABLE IN THE STOCK SYSTEM UNDER NSN 6635-01-534-2512) WILL BE A USEFUL MAINTENANCE AND TROUBLESHOOTING TOOL FOR VCHT SYSTEMS. THIS VACUUM LEAK DETECTION DEVICE IS RECOMMENDED FOR ALL SHIPS IN THE DDG-51, LPD-17, AND PC-1 CLASSES, AND HULLS LCS-1, LCS-2 AND CVN-77. ALL THESE SHIP CLASSES/SHIPS HAVE SIMILAR, BUT NOT EQUAL, VCHT SYSTEMS AND ALL CAN BENEFIT FROM USE OF THIS DEVICE.
C. IT IS NOT MANDATORY THAT THIS DEVICE BE PROCURED FOR INDIVIDUAL SHIPS AT THIS TIME. IT IS ENVISIONED THAT THIS DEVICE WILL INITIALLY BE UTILIZED BY LOCAL RMCS IN SUPPORT OF INDIVIDUAL SHIP TECH ASSIST VISITS. A DECISION TO OUTFIT INDIVIDUAL SHIPS, OR HOMEPORTS WITH A POOL OF THESE DEVICES WILL BE MADE BASED ON ACTUAL DEVICE USAGE.
4. ILS IS IMPACTED AS FOLLOWS:
A. TECH MANUALS: SECTION 4 (SEWAGE AND GRAY WATER) OF S9086-T8-STM-010 REV 05, NSTM CHAPTER 593 - POLLUTION CONTROL, WILL BE UPDATED TO INCLUDE INFORMATION ABOUT THE VACUUM LEAK DETECTION DEVICE AS AN ADDITIONAL TROUBLESHOOTING TOOL IN VCHT SYSTEMS; TMDER TRACKING NUMBER N65540-09-DU15 APPLIES. THERE IS NO IMPACT SHIP SPECIFIC OR EQUIPMENT TECHNICAL MANUALS.
B. OSS: THERE IS NO IMPACT TO SEWAGE DISPOSAL OPERATING SEQUENCING SYSTEM (SDOSS).
C. SUPPLY SUPPORT/APLS: ALLOWANCE PARTS LIST (APL) 46A090029 HAS BEEN DEVELOPED IN SUPPORT OF THE CTRL UL101 VACUUM LEAK DETECTOR. IF THE CTRL UL101 VACUUM LEAK DETECTION DEVICE IS PROCURED BY SHIP'S FORCE, SUBMISSION OF A CONFIGURATION CHANGE FORM (OPNAV 4790 CK IN ACCORDANCE WITH OPNAVINST 4790.4B) WILL BE REQUIRED TO ADD THE APL TO THE SHIP'S COORDINATED ONBOARD SHIPBOARD ALLOWANCE LIST (COSAL).
D. PMS: A NEW UNSCHEDULED MAINTENANCE REQUIREMENT CARD (MRC) IS BEING DEVELOPED TO PROVIDE PROCEDURES FOR USING THE CTRL UL101 VACUUM LEAK DETECTOR. IT WILL BE ADDED TO THE APPLICABLE 5931 SERIES MAINTENANCE INDEX PAGES (MIPS) FOR LCS-1 (5931/025), LCS-2 (TBD) AND CVN-77 (5931/008) SHIPS; AND DDG-51 (5931/016), LPD-17 (5931/026) AND PC-1 (5931/019) SHIP CLASSES. SPECIAL PROJECT PS-6932-09 APPLIES.
E. CMP: THERE IS NO IMPACT TO EITHER THE SURFACE SHIP INTEGRATED CLASS MAINTENANCE PLAN OR THE AIRCRAFT CARRIER CLASS MAINTENANCE PLAN.
5. FOR DDG-51 CLASS SHIPS ONLY: ADDITIONAL TROUBLESHOOTING INFORMATION RELATED TO VACUUM LEAK DETECTION FOR DDG-51 AND DDG-52AF VCHT SYSTEMS CAN BE FOUND IN COMPUTER-BASED TRAINING (CBT) AVAILABLE ON NAVY KNOWLEDGE ONLINE (NKO) WEB SITE AT HTTPS WWW.NKO.NAVY.MIL. DDG-51 VCHT AND GRAYWATER SYSTEMS NAVY ELEARNING COURSE (CATALOG CODE NAVSEA-VCHT51-1.0) AND DDG-52AF SHIPS VCHT AND GRAYWATER SYSTEMS NAVY ELEARNING COURSE (CATALOG CODE NAVSEA-VCHT-01) ARE AVAILABLE UNDER NAVY LEARNING CENTERS & PROGRAMS/CENTER FOR NAVAL ENGINEERING (CNE)/GENERAL ENGINEERING TRAINING IN NKO'S NAVY ELEARNING PORTAL.
6. THIS ADVISORY WILL REMAIN IN EFFECT UNTIL NSTM 593 HAS BEEN UPDATED AND PMS HAS BEEN UPDATED.
7. PER REF A, THE NAVSEA TECHNICAL WARRANT HOLDER FOR NON-OILY WASTEWATER SYSTEMS CONCURS WITH THE ISSUE OF THIS ADVISORY.
8. REQUEST PASS THIS ADVISORY TO ALL APPLICABLE SHIPS FOR INFORMATIONAL PURPOSES.//
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Vacuum Leak Detector

Current Efforts by NSWCCD Code 631 (Wastewater ISEA)

VCHT Instrumentation Isolation Testing (VCHT-IIT)

- NSWCCD is currently testing non-diaphragm type isolators to determine if they can be used to prevent sewage debris from effecting instrumentation performance, and will test both transducers and vacuum switches to determine compatibility.
- Testing will result in configuration design proposals compatible with existing DDG-52AF VCHT systems for future validation testing.
- Shipboard testing would be necessary to develop an SCD that properly addresses candidate systems based on configuration and VCHT system data.

NSWCCD Efforts Related to Current Advances in VCHT Systems

- In response to future designs incorporating pressure transducers, NSWCCD Code 631 will test the proposed DDG-113AF pressure transmitter (also on CVN-77) as part of VCHT-IIT.
- NSWCCD developed a conceptual design to interface pressure transducers with existing DDG-52AF ejector pump controllers, and is building a prototype as part of VCHT-IIT.
- If both transducers and vacuum switches are compatible with isolation, side-by-side testing can be accomplished during shipboard testing.
- A unit that includes pressure transducers could also be used to perform advanced system troubleshooting and validation testing of future proposed design changes (new ejector)